Proposal Number:

An Operational Real-time Hurricane Wind Analysis System

A FY2001 proposal to the Joint Hurricane Transition Center

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Background and Justification

Tropical cyclone forecasters and research scientists have few tools that enable real-time examination and

analysis of hurricane wind observations. Hurricane wind fields are determined subjectively based on the specialist's interpretation of flight-level reconnaissance data, satellite observations, pressure-wind relationships and available surface data. These fields are represented in a coarse fashion by text portions of the NHC forecast product as radii (from the storm center) of 34 kt, 50 kt, and hurricane force winds in four compass quadrants relative to north. Advances in computing and communications have made it possible to obtain tropical cyclone wind observations in near real-time (Burpee, et al., 1994, Griffin, 1992, Powell et al., 1996, 1998). Through several years of research and development, HRD has developed an interactive real-time hurricane wind analysis system (called H*WIND) which allows scientific users to select a storm, graphically examine and quality control the real-time or retrospective data collected during the time period of interest, analyze and archive the wind field, and create a variety of graphical analysis products or data sets derived from the wind field. HRD has continually improved and field tested H*WIND by conducting real-time wind analyses on an experimental basis, delivering products to NHC forecasters on a 3-6 h operational cycle. The immediate goal is to complete development of H*WIND and transition the technology to the National Hurricane Center for operational use over a 2 year period.

H*WIND, will allow forecasters to interact with the observations, perform quality control, and select from a menu of several graphical products depicting meteorological fields for storm diagnosis and forecast guidance. The HRD approach to hurricane wind analysis has evolved from a series of peer-reviewed, scientific publications analyzing landfalls of major hurricanes from 1979-1998 (Powell and Houston, 1996, 1998, Powell et al., 1998). H*WIND has reached its current state as a result of leveraged research support from many sources. HRD base funds have declined annually over the past 20 years and have never been sufficient to fully support H*WIND development. H*WIND has been the product of leveraged incremental support from research efforts funded since 1990 by NOAA's Coastal Ocean Program, Florida Power and Light Company, the National Institute for Building Sciences, the U.S. Weather Research Program, and NOAA's HPCC and ESDIM programs. Since 1994, several hundred HRD wind analyses have been conducted on an experimental basis to create real time hurricane wind field guidance for forecasters at the National Hurricane Center. H*WIND was first demonstrated at the NOAATech 2000 Conference where it won the "Best JAVA Implementation" award.

NHC has identified the following activities associated with the transition of H*WIND into TPC operations:
A) converting software to existing TPC IT architecture, or if not possible obtain/install native h/w and s/w.
B) user support-staff training, C) user analysis time <= 20 min, D) user-specified sfc. reduction factors, E) export of wind radii to ATCF, F) manual override of objective analysis contours, G) internet delivery to end users as stand alone product. HRD believes that all the above activities are achievable but, given that JHT resources will likely be less than half of what is necessary to support HRD's current H*WIND effort, it will be necessary to determine limitations and required improvements in the current system through a program of active training and testing in cooperation with TPC forecasters. This process will determine which capabilities are most important, and how to transition H*WIND in the most cost effective manner. In particular, (G) may be best left for TPC to incorporate once the system has been transferred to operations.

Work Plan

The first year of the transition process would involve facilitator training of NHC personnel to work side by side HRD scientists using the current version of the analysis system to perform retrospective and realtime wind analyses on NHC's warning and forecast cycle (subject to recon availability, TPC forecaster workload, and resources for HRD overtime). HRD will continue their regularly scheduled realtime analysis effort as a part of the Hurricane Field Program, the only difference is that some of the realtime analyses (a goal of one analysis per storm) will be conducted by TPC personnel with HRD assistance. Operational requirements will be evaluated, prioritized, and incorporated through incremental improvements to H*WIND over the two year period. At the end of the two year program, the final version of H*WIND code will be maintained by NHC and will run on NHC hardware. NHC will need to provide a liason to assist in the delivery of products to selected end-users for feedback. HRD recognizes the time demands on hurricane specialists. Much of this effort will go into establishing a balance between automating portions of the system to save time while giving the specialists a chance to practice their trade by analyzing and interacting with observations of the quantities they are forecasting. Progress will be assessed by numbers of analyses created by HRD and NHC per storm, statistics on differences between advisory and analysis wind radii and max winds, and end-user feedback. The final version of H*WIND will come with online help to allow any forecaster to become proficient without special training. The success of this effort depends on active NHC participation of TPC forecasters in the training and analysis effort, the most timely possible access to all potential data platforms including Air Force recon observations (through liason with TPC LDM, ATCF, and NCEP data flow experts), active promotion of HRD's role in developing the technology, and assistance in enlisting additional federal and state partnerships to share in research and development costs.

TPC Investment

Initially, NHC/TPC will not need any new equipment since HRD already has research servers and extensive DB software in place. HRD will continue to use their own H*WIND-related hardware and software for research purposes but will need to upgrade memory and processors if performance becomes an issue during operational testing. At the end of the 2 year period, NHC will be required to budget for operational hardware, software, JAVA and IT DB administrator training, and 24/7 operational maintenance and support. A preliminary estimate of the required TPC investment is $45K for two Solaris servers, $25K for Oracle database software (8 simultaneous users and support), and ~$15K for JAVA programming and Oracle database administration training for existing personnel. With support from JHT or NHC for follow on years, HRD could continue to develop improved versions of H*WIND. HRD will provide limited database specialist support to assist with installation and database schema design only. NHC/TPC will work with HRD to deliver various data sources from the Local Data Manager (LDM), ATCF, CARCAH, NCEP, NESDIS, and other sources in the most timely possible manner using their own scripts or those provided by HRD.

Transition Issues

On March 27, 2001 HRD and TPC scientists met to discuss H*WIND transition. The H*WIND analysis process was demonstrated step by step to illustrate limitations in the current system and identify some immediate needs.

Platform and Software Issues

H*WIND is written in JAVA and the current version of H*WIND requires the client machine to run the Java 1.3 virtual machine or use X windows Display from an HRD application server located at NHC. JAVA 1.3 is not available for HP hardware. Running as an X display is limited to the UNIX environment and is relatively slow due to the overhead of X over the network and the fact that HRD's servers are really workstations with limited memory for 2-3 simultaneous users. For the 2 year period we will continue to run H*WIND through an X display. Longer term there are many advantages to developing H*WIND as a web browser application. HRD was in the process of beginning this approach before the JHT came along and will continue this effort while trying to recruit additional federal and state partners to share in the development costs. Advantages to a web browser client include complete platform independence (e.g. users of UNIX and non-UNIX hardware could run H*WIND) and the ability of other potential JHT contributors (CPHC, JTWC, WMO Regional Centers) to run H*WIND without investing in their own server hardware and maintenance. Centrally located software, servers, and database provide the web version increased access speed to the database and analysis server as they would be closely located to the web server hosting the web-based H*WIND. The display of the web version of H*WIND is done locally on the web browser of the client machine. Other advantages include decreased maintenance costs. Since there is only one client platform to develop for, no time has to be spent getting the software to work with different JAVA virtual machines although some testing will be required for different web browsers. For example, no resources have to be spent distributing software to CPHC since they could run off TPC's servers. While the present proposal only addresses transition of the current H*WIND system, HRD will continue to perform research and development on a web browser version of H*WIND which could ultimately become a future operational version.

Science Issues

On the meteorological side, improvements will be required to provide a default automation of most storm track, observation mapping, and analysis archive activities and allow for the use of first guess background fields generated from prior analyses. Automating storm track positions will focus on Air Force and NOAA tasked recon vortex fixes and ATCF preliminary best track fixes. With automated storm tracking and data updates forecasters could periodically examine the latest observations and conduct an analysis much faster than the current version and within the desired <= 20 min time limit. The analyses are only as good as the data that go into them. Constant striving for the most timely possible access to the observations will make H*WIND a true realtime tool. HRD needs TPC assistance to provide access to the most timely data feeds (such as NCEP, ATCF, and LDM) and to enlist CARCAH cooperation to make recon data immediately accessible to H*WIND when they reach the building. The analyses need to be available graphically upon conclusion for immediate feedback to the forecaster and to provide time to iterate on an acceptable product (right now H*WIND must be

restarted to redo an analysis). Automatic annotation and archival of analyses and wind observation maps will be required to provide wind radii, maximum wind information, and information on data contributing to the analysis. Wind radii and max wind information will need to be output to ATCF format and automatically transmitted to the ATCF upon committing an analysis. Incorporation of an improved objective reduction of flight level winds is in process, taking advantage of recent results from GPS sonde research. User-supplied reduction factors would have to be developed with TPC feedback. Access to the TPC intranet for timely delivery of analysis products to end users will also be required.

The following items may be desirable but resources are insufficient to support them at present. Automating acquisition of storm center fixes from satellite and radar platforms could be useful for storms outside recon range and for storms progressing inland. H*WIND currently only analyzes surface winds, much additional effort would be required to include the capability of analyzing other fields or producing additional products (wind swaths, time series, pressure, temperature, convergence, vorticity and deformation) and conducting analyses at other levels. Observation weights are currently set subjectively by platform type according to analyst experience; it may be useful to implement a variational approach to set weights and perform automated quality control if future resources warrant. Additional useful features include identifying the location of the strongest and most recent winds per platform, and a decimator tool to assist examination of high resolution observations while preserving maxima e.g. 30 s aircraft data resampled to 1 min or 2 min. An issue for JTWC, if they become members of the JHT, is that the analysis algorithm has difficulty analyzing a storm in the vicinity of the 180 meridian.

HRD Budget

Year 1 (For only changes to make current H*WIND operational)

Requested Resources
CIMAS Labor $116.5k (DB Specialist 50%, 1 FT programmer, 2 PT programmers 50%)
CIMAS fringe benefits and OH $64k
NOAA labor $17k (Physicist, 20%)
NOAA fringe benefits and overhead $14.3k
Total labor and benefits: $211.8 k

HRD (or other program) Contributions
HRD scientist labor (PI 30% and 3 meteorologists 25%) (~$65k)
Fringe benefits $13.6 k
Overhead $40.9k
Total NOAA HRD labor, OH and benefits $119.5k

programmer training $13k
travel $8k

software $10 k
hardware $25k
* OT costs of ~ $25K will cover avg. season analyses on weekends and evenings (16/7, 24/7 landfall situations).

Total HRD and other program contributions: $200.5K

Year 2 Same budget as year 1

Project-related References

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